

SUPPORT FOR AN INTEGRATED CIRCUIT PACKAGE HAVING A COLUMN GRID ARRAY INTERCONNECT

1 TECHNICAL FIELD

2 The present invention relates generally to printed circuit board (PCB) technology,
3 and, in particular, to devices that mechanically support column grid array interconnects
4 and methods of using such devices.

5 BACKGROUND OF THE INVENTION

6 Package to board interconnection has been accomplished using many different
7 methods over the years. The industry was initially dominated by pin-through-hole (PTH)
8 lead attachment with "integrated circuit" packages that were rectangular in shape and had
9 rather large leads extending from the long side of the rectangle. These devices were
10 limited in lead count and provided very rugged interconnection between the package and
11 the printed circuit board (PCB). PTH technology was gradually replaced by surface
12 mount technology in order to increase the number of leads, and to improve the
13 automation of the process for attaching the devices to the boards. In the recent years, a
14 new packaging technology, known as "ball grid array" (BGA) technology, has been
15 developed. A BGA package consists of a silicon chip attached to the surface of a substrate.
16 The substrate has printed circuitry that provides interconnect points for the silicon chip on
17 the top surface, connected by fine pitch traces to an array of pads on the bottom surface.
18 The pads on the bottom surface have attached solder spheres that serve as the interconnect
19 points for the package to the PCB. The BGA technology allows designs with lead counts
20 of over 1000 input/output points. In addition to the high lead count, this technology also
21 affords many other benefits that include ease of handling, simplified device attachment and
22 overall cost effectiveness compared to fine pitch, perimeter leaded devices.

23 The BGA technology, however, has a compromised reliability in thermal cycling. A
24 perimeter leaded device with gull wings can be subjected to many thermal cycles without
25 encountering stresses due to thermal coefficient of expansion (TCE) mismatch between the
26 PCB and the device. BGA packages, on the other hand, are connected to the board with a
27 rigid structure of solder spheres (oval shaped after reflow). When the device is operated,
28 waste heat builds up and a temperature differential between the device and the board is
29 created. The temperature differential, as well as the differences in TCE between the device
30 and the board, will lead to stresses in the solder sphere attachment points, which creates a
31 high risk of fatigue failure.

1 One solution to the thermal stability problem is the column grid array (CGA)
2 technology, which utilize a flexible column lead in place of the solder spheres. The column
3 leads are designed to have a lower stiffness than a solder sphere and a higher offset distance
4 between the device and the PCB. These two features enable the leads to flex with less
5 stress as the dimensional expansion between the device and the PCB varies. The higher
6 offset distance reduces the stress by the square of the distance between the device and the
7 PCB.

8 CGA has been widely used in high reliability applications. However, the thin and
9 tall solder column interconnects in CGA are susceptible to damage due to short-term
10 dynamic load during shock, vibration, and creep under long-term static compressive load.
11 For example, a thermal solution that is directly attached to an integrated circuit (IC)
12 package will subject the solder columns to shock and vibration impact, as well as long-
13 term compressive load, and therefore should have a light mass to avoid causing excessive
14 damages to solder columns. This limitation becomes a severe problem for large and high
15 power IC packages that need thermal solutions with a high retention load due to heat sink
16 mass or thermal interface requirement. The high retention load often exceeds the
17 maximum long-term compressive load of the solder columns and causes excessive creep,
18 bending, bucking of the solder columns, which finally results in interconnect failures such
19 as shorting or joint failure. Accordingly, the solder columns in a CGA connection often
20 need to be mechanically supported in these applications. The supporting device also
21 needs to be fully fastened, so that the supporting device will not get loose and cause
22 damages by itself. Commonly used supporting devices include posts attached between
23 heat sink and PCB, and external frame or corner support. These devices, however, often
24 require complicated attaching process using epoxy adhesives and consume valuable PCB
25 real estate.

26 **SUMMARY OF THE INVENTION**

27 Mechanical support of an IC package having a CGA interconnection with a PCB
28 may be provided by inserting shims between the IC package and the PCB. The shims
29 may be mechanically and removably fastened to the PCB and may be designed in such
30 shapes that the shims can be easily inserted into the space between the IC package and the
31 PCB, but cannot come into contact with the solder columns of the CGA to cause damage
32 or shorting. The maximum retention load constraint of the IC package may be
33 substantially eliminated and a wide variety of thermal solution implementations may be
34 enabled without compromising reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments described herein are better understood in conjunction with the following drawings, in which:

Figure 1 is a top view of an IC package supported by supporting devices of the embodiments described herein.

Figure 2 is an isometric view of one corner shim of the embodiments described herein.

Figures 3a, 3b, and 3c depict three embodiments of fastening a shim to a PCB with a screw.

Figures 4a and 4b depict an embodiment of fastening a shim to a PCB with a dimple.

Figure 5 is a flow chart depicting a method of using the supporting device of the embodiments described herein.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description is presented to enable any person skilled in the art to make and use the embodiments described herein. For purposes of explanation, specific nomenclature is set forth to provide a thorough understanding. However, it will be apparent to one skilled in the art that the specific nomenclature is not required. Descriptions of specific applications are provided only as representative examples. Various modifications to the preferred embodiments will be readily apparent to one skilled in the art, and the general principles defined herein may be applied to other embodiments and applications. The present inventions are not intended to be limited to the embodiments shown, but are to be accorded the widest possible scope consistent with the principles and features disclosed herein.

The embodiments described herein are generally directed to devices and methods for supporting CGA solder columns of an IC package to prevent damage to the solder columns due to shock, vibration, and long-term compressive load.

With reference now to Figures 1 to 5, various embodiments of a supporting device will be described. As will be described in more detail below, the supporting device may be used in a variety of configurations to provide mechanical support for CGA solder columns on an IC package.

Figure 1 shows an embodiment of the supporting device. In this embodiment, the supporting device is in the form of a corner shim 101. The shim 101 can be made of any material that is mechanically strong enough to support an application specific integrated

1 circuit (ASIC) 103. Examples of the shim material include, but are not limited to,
2 plastics, ceramics, metal, and metal alloy. Preferably, the shim 101 is made of a material
3 with a coefficient of thermal expansion (CTE) that closely matches the CTE of the solder
4 columns. A shim 101 with a matching CTE may be preferred in high temperature
5 applications such as a burn-in test of semiconductor wafers and high power IC packages.
6 In this embodiment, a shim 101 is placed at each corner of the ASIC 103. However, it is
7 understood that the number of shims used in a particular application may vary according
8 to the particular requirement of the application, and that the shims 101 may be placed in
9 other depopulated areas. For example, the shims 101 may be placed along the sides of the
10 ASIC 103, if there are depopulated areas along the side of the ASIC 103 that allow the
11 insertion of the shim 101. Preferably, the PCB 105, ASIC 103 and shims 101 are
12 designed to accommodate each other so that shim installation can be automated.

13 There is no particular limitation on the size and shape of the shim 101. Generally,
14 the size of the shim 101 is minimized to reduce consumption of PCB real estate. In the
15 embodiments shown in Figures 2 and 3, the shims 101 are designed in such a shape that
16 an extrusion 111 of the shim 101 can be inserted into the space between the underside of
17 the ASIC 103 and the topside of the PCB 105. The extrusion 111 may have a thickness
18 that is smaller than the distance between the ASIC 103 and the PCB 105, so that the
19 extrusion 111 may be slipped into the space between the ASIC 103 and the PCB 105
20 without stretching the solder columns 107. However, the extrusion 111 may be thick
21 enough to provide mechanical support to the ASIC 103 and prevent shorting or joint
22 failure due to creeping of the solder columns 107 under a long-term compressive load. In
23 other words, there is preferably a small gap 125 between the extrusion 111 and the ASIC
24 103 immediately after the shim 101 is installed (Figure 4A). As shown in Figure 4B,
25 when the apparatus is in use, the solder columns 107 will start to creep over time due to
26 stress and the gap 125 will be closed. When the upper surface of the extrusion 111 comes
27 into contact with the undersurface of the ASIC 103, the ASIC 103 is fully supported by
28 the shims 101 and the stress on the solder columns 107 is relaxed.

29 The shim 101 may also be designed in such a shape that, after being fully inserted
30 between the ASIC 103 and the PCB 105, the extrusion 111 of the shim 101 will not come
31 into contact with any of the solder columns 107 of the ASIC 103. In the embodiments
32 shown in Figures 2 and 3, this goal is achieved by the design of a base 113, which would
33 come into contact with the edges of the ASIC 103 and stop the advance of the shim 101
34 before the extrusion 111 comes into contact with any of the solder columns 107.

1 In order to prevent any undesired movement of the shim 103, the shim 103 may be
2 mechanically and removably fastened to the PCB 105. The shim 103 may be fastened to
3 the PCB with a screw or with a snap-and-catch mechanism such as a dimple 119.
4 Figures 3a to 4b illustrate several embodiments of the fastening mechanism. With
5 reference now to Figure 3a, the shim 101 is fastened by a screw 115 from the bottom of
6 the base 113 through a hole 121 on the PCB 105. Alternatively, the screw 115 may be
7 installed from the top of the base 113, through the base 113, through the hole 121, and
8 into a bolster 117 underneath the PCB 105 (Figure 3b). In another embodiment, a
9 threaded adaptor 127 is inserted into the hole 121 to convert the unthreaded hole 121 into
10 a threaded hole for the installation of the shim 101 (Figure 3c).

11 With reference now to Figure 4a, the shim 101 is pushed into a position so that the
12 dimple 119 on the base 113 of the shim 101 clicks into the hole 121 on the PCB 105 and
13 immobilizes the shim 101. The dimple 119 does not have to have a tight fit with the hole
14 121, so long as horizontal movement of the shim 101 is restricted by the dimple 119 and
15 the matching hole 121 and so that the shim 101 cannot come into contact with the solder
16 columns 107. Since the vertical movement of the shim 101 is restricted by the extrusion
17 111 in between the ASIC 103 and the PCB 105, the shim 101 is properly secured on the
18 PCB 105. Over time, when the gap 125 is closed due to minor creeping of the solder
19 columns 107 (Figure 4B), the shim 101 will be completely immobilized. It should be
20 noted, however, that the shim 101 can be removed at any time and reinstalled at the same
21 or different location.

22 Figure 5 depicts a method 500 for mechanically supporting an IC package having
23 a CGA interconnection with a PCB. The method 500 preferably comprises the steps of
24 inserting shims between the IC package and the PCB (step 503), and fastening the shims
25 to the PCB to secure the support to the IC package and prevent damage to the solder
26 columns of the IC package by undesired movement of the shims (step 505). Preferably,
27 the shims are inserted after the IC package is solder attached to the PCB, so that the
28 presence of the shims will not interfere with the soldering process. Shims 101 may be
29 removed for rework of the ASIC 103 and reinstalled after the rework of the ASIC 103.

30 The preferred embodiments of the supporting device of the present invention are
31 intended to be illustrative and not limiting. It should be understood that modifications
32 and variations can be made by persons skilled in the art in light of the above teachings.
33 Therefore, changes may be made in the particular embodiments disclosed which are
34 within the scope of what is described as defined by the appended claims.